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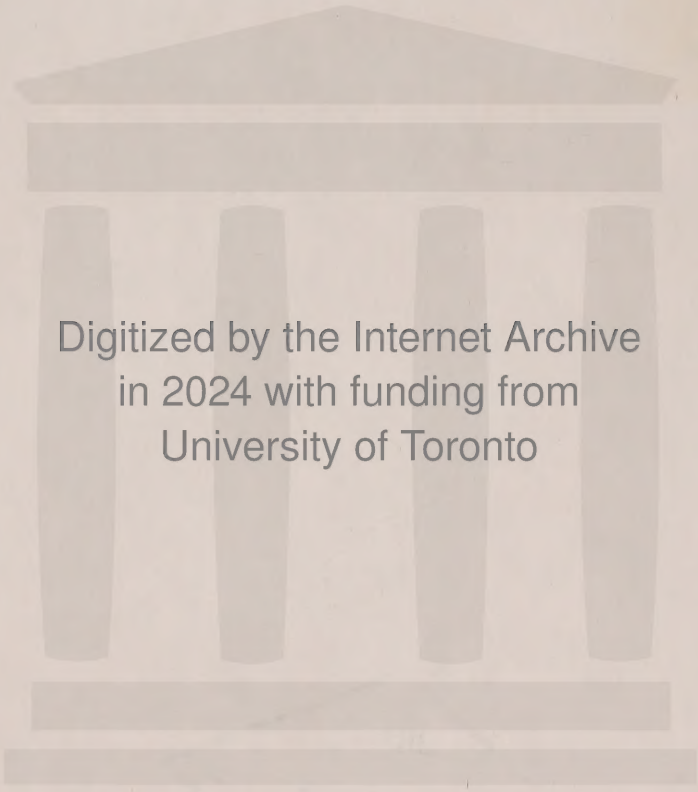
Ontario Ministry of Labour
The Honourable John P. MacBeth Q.C., Minister
R. D. Johnston, Deputy Minister

Research Branch
September 1974

Some Concepts and Methodologies in Manpower Forecasting



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Prepared by
Farid Siddiqui

FOREWORD

The provision of accurate information that can contribute to improvement of the working of the labour market is a major responsibility of the Ontario Ministry of Labour. Presently there is much public concern about the adequacy of supplies of certain types of manpower for meeting the needs of industrial expansion, particularly in response to the energy crisis. Yet just a few years ago, there was widespread fear of over-supply of highly qualified manpower. There is no doubt that occupational labour markets change rapidly, and new imbalances are constantly emerging.

In this environment, it is important to be able to monitor the current situation and to forecast future trends in manpower requirements and supplies. Many private firms and public institutions are now attempting to forecast their manpower requirements. Many associations, agencies, and localities are undertaking specific types of manpower forecasts. However, in many cases what is lacking is an adequate methodology for such forecasts based upon an understanding of the principal concepts involved in manpower forecasting.

This monograph lays bare these concepts and describes a methodology for manpower forecasting. The monograph should be of interest to persons who attempt to undertake manpower forecasts; to those who use manpower forecasts; and to those who read about manpower forecasts and would like to understand their limitations. The monograph differs from nearly all other publications of the Research Branch in that it concentrates on concepts and methodologies rather than the presentation of factual information.

The monograph was prepared by Dr. Farid Siddiqui. It grew out of his Ph.D. Thesis which was accepted this year at the University of Toronto and his work in the Research Branch in the manpower information area.

J. R. Kinley
Director
Research Branch

CONTENTS

CHAPTER I

SOME ECONOMIC CONCEPTS INVOLVED IN MANPOWER FORECASTING

The rationale for the development of manpower forecasts is to provide relevant information to decision-makers, in order to prevent imbalances in the labour market, and to facilitate career decisions and the planning of educational facilities. Specifically, these decision-makers include the employers, members of the labour force, students, educational administrators, and other policy-makers in the public and private sectors. The main use of the forecasts is for medium and long-term guidance for public policy and private or institutional decision making as opposed to short-term labour market monitoring aimed at resolving current imbalances. The information necessary to achieve these objectives is obtained through the forecasting and analysis of manpower requirements and supplies. The analysis required calls for the integration of two primary areas of related study. These are (i) forecasting manpower requirements, and (ii) forecasting manpower supplies.

I. FORECASTING MANPOWER REQUIREMENTS

In general, the labour market determines the requirements in terms of quantity and type of trained manpower. Trained manpower is supplied through on-the-job training, immigration, and the educational system. If policies relating to the future supply of labour are undertaken without regard to anticipated demand, serious imbalances are likely. Before policy can be made to forestall manpower imbalances, the nature and extent of the potential mismatches in labour supply and demand must be forecast. Obviously, the separate projections of demand and supply have to be comparable. Also, they should be formulated and reconcilable in a way useful for policy considerations.

From the point of view of educational, immigration, and other labour market policy, the question arises as to the appropriate level of disaggregation of the forecasts. This is a critical problem in the sense that in most developed economies, the bottlenecks occur because of insufficient supplies of people with specific types of occupational training and experience. The bottlenecks of this nature can occur even when the aggregate requirements for labour may be equal to the aggregate supplies. If the preparation

for most highly skilled manpower is quite specialized, then the appropriate forecasts cannot be based on highly aggregated categories.

A. Forecasting Occupation Requirements (Gross)

One of the most neglected aspects of manpower forecasting has been the clear specification of what is being projected. The intent in this section is first to define what is meant by 'manpower requirements' and how this concept differs from that of the 'demand for labour'. To understand the mechanism which results in a specific occupational composition at any point in time, it is necessary to deal with the concepts underlying the allocation of labour among occupations, geographic regions and industries. Thus, a discussion of the factors affecting the manpower requirements and supply is given as the second part of this section. The third part of this section deals with the working of the labour market for highly skilled manpower. The effects of the supply conditions upon the amount demanded, involving what is often referred to as the substitution problem, is explored in the fourth part of this section. Finally, there is a survey of the methods for forecasting occupational requirements, along with a discussion of the recent studies which have used these methods.

1. The Meaning of Manpower Requirements

The meaning of manpower requirements has been the source of much confusion. It is necessary that a distinction be made between the terms 'manpower requirements' and the 'demand for labour'. In microeconomic theory, the demand for a particular category of labour is defined in terms of a schedule showing the relationship between quantities of labour demanded and a series of possible wage rates. It is assumed that employers will be willing to hire varying quantities of workers depending on the wage that must be paid. Similarly, supply is used in the same way to refer to the varying numbers of workers who would make themselves available at corresponding wage rates.

The term 'manpower requirements' relates to the functional (occupational) composition of employment that will be necessary, if certain social and/or economic targets are to be achieved.[1] The concept of manpower requirements is, therefore, more a technological one than an

[1] H. S. Parnes, "Manpower Analysis in Educational Planning", in Economics of Education, M. Blaug (ed.), (Harmondsworth, Middlesex, England: Penguin Books Ltd., 1968), p. 267.

economic one. It is unlikely that Canada's current standard of public services and the level and composition of GNP could be maintained, if the Canadian labour force had the same occupational structure as some less developed country such as Chad or Haiti. On the other hand, it is difficult to ascertain just how much flexibility there is in the economy. If there is great flexibility so that the targets can be achieved by nearly any occupational composition, then the concept of manpower requirements becomes meaningless. It may be the case that if the quality and structure of the educational programmes remain the same over a given time period, then the flexibility in the occupational requirements of the economy would be reduced as more and more advanced technologies are employed in the production activities in that time period. At the extreme, a unique occupational composition may be necessary in order to achieve given social and economic targets. The adaptation of the educational programmes to the changes in the production sectors, however, suggest that such a situation would never occur. Since in reality we operate at some unknown point in between these two extremes, the concept of manpower requirements need not be taken to imply that there is a unique occupational composition for a particular level and composition of GNP, and that this level of GNP cannot be sustained with any other occupational composition. A more realistic view of manpower forecasting would be to describe the range of feasible sets of manpower requirements for a given level and composition of GNP. After defining the feasible sets of manpower requirements, one may attempt to select the optimal set according to a specific criterion. Two possible criteria are minimizing the costs of education, or minimizing the total employment costs for the manpower set. These criteria may give different solutions.[1]

Departing from the fixed relationship approach, which assumes a unique relationship between various types of manpower inputs and economic output, W. Lee Hansen[2] has suggested a neo-classical approach to defining manpower requirements. The three alternative definitions of manpower requirements that he puts forward are:

i) the numbers of workers of a particular occupational or educational category needed to maintain the existing pattern of relative earnings differentials;

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[1] M. L. Skolnik, and C. S. Smith, "Selecting an Optimal Set of Manpower Requirements Where Skill Substitution is Possible", British Journal of Industrial Relations, Vol. X, No. 2, pp. 256-269.

[2] W. L. Hansen, "Labour Force and Occupational Projections", in Proceedings of the 18th Annual Winter Meeting, New York, December 28-29, 1965 (Madison, Wis.: the Industrial Relations Research Association, 1966).

ii) the numbers of workers needed to maintain the existing patterns of rates of return in different occupations; and

iii) the numbers of workers needed to equalize rates of return among occupations.

It should be recognized that the implications of each of the above definitions are quite different. They all have to do with the balance between the number of workers demanded and the number supplied. Under these definitions, it is essential that we must also have information on potential manpower supply in order to make any sense out of these projections of the manpower requirements. The information which would be of great value is the magnitude and direction of the differences between the projected manpower requirements and the potential supplies at any point in time.

The forecasting of manpower requirements in accordance with Hansen's definition, therefore, involves: (a) the projection of manpower requirements based on some social and/or economic targets, (b) the projection of potential supply, and (c) the study of the implications of the magnitude and direction of the differences between the projected manpower requirements, and the potential supplies on the relative earnings differentials during the projection period.

There is a tendency to put supply and demand in separate boxes, even though they are always interacting. The intention in the next section is to explore the factors affecting the supply of and demand for labour and their interactions.

2. Factors Affecting the Manpower Requirements and Supplies

From the point of view of manpower forecasting, it is essential that a distinction be made between the factors affecting the overall demand for labour and the factors affecting the allocation of labour among occupations, geographic regions and industries, even though there exists a close inter-relationship between them. The inter-relationship exists because the more efficiently the market allocates labour the less overall unemployment. On the other hand, when overall unemployment is low the allocation problems can be resolved more readily. The distinction is made because of the nature of the policy measures required in each case. While the overall demand for labour can be influenced by means of monetary and fiscal measures, specific manpower policies are required to deal with problems relating to the allocation of labour.

Since labour is one of the factor inputs in the production process, the level of demand for a given type of labour should respond to one or more of the following factors:

i) A change in the pattern of demand for goods and services and/or social objectives, caused either by a change in tastes or income of the buyers or a change in prices.
ii) A change in the technology employed in the production process causing a change in the ratios of the factor inputs.
iii) A change in the relative prices of other factor inputs, which are complementary to or can be substituted for a particular type of labour.

In short, therefore, the demand for a given type of labour can be affected by a change in the product market and by a change in other factor markets, as well as by changes in technology. Also, since one type of labour could be substituted for other kinds of labour, the demand for a given type of labour can be affected by wage rates for the substitutable kinds of labour.

The supply of a given type of labour to a given industry in a given locality may change in response to changes in one or more of the following factors:

i) A change in the wage differentials for different kinds of labour.
ii) A change in the wage differentials among geographic regions.
iii) A change in the wage differentials among industries for the same kinds of workers.
iv) A change in the non-wage aspects of employment.
v) A change in the attitudes about and assessment of other types of work.
vi) A change in the educational opportunities and the costs of acquiring various skills.

If it is assumed that the workers are reasonably mobile and responsive to improved income opportunities, then the supply of a given type of labour will vary with changes in the relative wage rates caused by shifts in the demand for different kinds of labour.[1] The supply and demand shifts are often inter-related with changes on one side of the market operating through the wage structure to induce changes on the other side of the market. Shifts in labour demand and/or supply result (not necessarily instantaneously) in changes in product prices, in the mix of product output, and in the relative earnings differentials as well

[1] J. Holland, S. Quazi, F. Siddiqui, M. Skolnik, Manpower Forecasting and Educational Policy, a report prepared for the Commission on Post-Secondary Education in Ontario (Toronto: Queen's Printer, 1972).

as in the deployment of manpower by occupation, industry and region.[1]

3. The Effects of Supply Conditions Upon Demand – The Substitution Problem

In economic theory an old and continuing argument has been whether at any point in time input coefficients can be varied in response to changes in relative supplies of various inputs without changing the level of output. In the context of manpower forecasting the argument has given rise to the question of the effects of supply conditions upon demand, frequently referred to as the substitution problem. In manpower forecasting, the question of substitution is generally ignored by assuming that, at any point in time, the number of workers demanded in a particular skill category is determined by the prevailing technological structure. In other words, it assumes that for a given level of output in a particular economic sector, the number of workers with particular skills required is fixed. This assumption is more than a convenience to simplify the task of manpower forecasting. In most of the forecasting models in wide use it is an unavoidable necessity.

Since all forecasts use historical data, the question of substitution possibilities occurs at two levels. The first has to do with the use and interpretation of the observed data on occupational inputs, and the second has to do with the extrapolation or forecasts of occupational inputs.[2] In order to deal with this question, one must be able to distinguish between changes in input coefficients which occur because of changes in technological structure, and those which occur because of substitution possibilities and changes in relative wages. If supply conditions do indeed affect input coefficients, then at the second level observed supply conditions present a source of bias in projecting future coefficients.

The lack of any concrete evidence on the contribution of changes in supply conditions to changes in the input coefficients, poses one of the

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[1] Arthur Kruger, "Micro-economic Theory: Labour Allocation and Manpower Policy", The Canadian Labour Force: Readings in Manpower Economic, Arthur Kruger and Noah M. Meltz (eds.) Centre for Industrial Relations, University of Toronto, 1968.

[2] R. G. Hollister, A Technical Evaluation of the First Stage of the Mediterranean Regional Project, Paris: Organization for Economic Co-operation and Development, 1967, p. 33.

most serious problems for manpower forecasting. The results of the little empirical research that exists in the literature are inconclusive, and often contradictory. For example, using an econometric approach, Skolnik[1] reported high substitution possibilities between engineers and technologists in Canada. Later using an interview case study method, the same author reported that there are few substitution possibilities between engineers and technologists in Canada. Skolnik suggested three possible reasons for the discrepancy between the results of the two studies. First, and probably most important, the econometric study allowed for longer-run adaptation to supply conditions than the interview study which focused on short-run behaviour. Second, he acknowledged that the data for the econometric study were poor, and some spurious correlation was possible. Third, he stated that there may be a general tendency for interview studies to give results that show less price-elastic behaviour than econometric studies.[3]

There are other studies where generalized statements about the possibilities of substitution have been made, based on very doubtful empirical evidence. For example, Hollister stated that, "if substitution possibilities were very limited then one would expect to find that the occupational coefficients[4] were roughly similar among countries for a particular sector".[5] Then, based on the observed variations in the occupational coefficients among Mediterranean Regional Project countries, he concluded that, "there is no indication that the occupational input per unit of output is technologically fixed".[6] The validity of his first statement could be challenged. Even if it is established beyond doubt that the substitution possibilities are zero, it does not necessarily follow that the occupational coefficients for a given sector should be of

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[1] M. L. Skolnik, "An Empirical Analysis of the Substitution Between Engineers and Technicians in Canada", Relations Industrielles, April 1970.

[2] M. L. Skolnik, and W. F. McMullen, An Analysis of Projections of the Demand for Engineers in Canada and Ontario: And An Inquiry into Substitution Between Engineers and Technologists. CPUO Report No. 70-2, Committee of Presidents of Universities of Ontario, 1970.

[3] Ibid., p. 58-59.

[4] An occupational coefficient for an industry represents the number of persons required in a given occupation in the industry per million dollars of output in Constant dollars.

[5] Hollister, op. cit., 1967, p. 48.

[6] Ibid., p. 48.

the same magnitude in all countries. Let us assume that comparable statistics for all countries exist. Even then the occupational coefficients could vary among countries for the following reasons:

i) because of the differences in the type of industries constituting the sector in different countries, for example, in one country the manufacturing sector may be strongly biased towards heavy industries and in others it may be that the bias is towards lighter industries;

ii) because of the differences in the technological structure among countries in the same type of industries;

iii) assuming that the technological structure is the same in countries for the same type of industries, that is, condition (ii) does not exist, even then the occupational coefficients could vary among countries because of: (a) the differences in the mix of the industries constituting the sector, (b) the differences in the degree of utilization of industrial capacity, and (c) the differences in the size and number of establishments of the same type of industry among different countries.

In spite of the above quoted remark, Hollister acknowledged that the reasons for the variation in occupational coefficients among the countries, besides some of the above factors, could be associated with the statistics themselves. Examples are the problems relating to the comparability of occupational classification of economic sectors among countries, and the measurement of output on a comparable basis for different countries.

In the context of manpower forecasting, it is not only essential to understand the process of substitution, or to establish the existence of specific substitution possibilities, but also to investigate the magnitude of their contribution to changes in input coefficients. There is very little literature which attempts to deal with the latter question. This is perhaps the main reason why in manpower forecasting the question of substitution is neglected.

4. Survey of Methods of Forecasting Occupational Requirements and Review of Recent Studies

There have been many surveys of the methods for forecasting occupation requirements, for example, by Bombach,[1] Emmerij and

[1] G. Bombach, "Manpower Forecasting and Educational Policy". Economic Journal, LXXVII, 306 (June, 1967), 262-287.

Thais,[1] Hollister,[2] Mehmet,[3] Meltz,[4] and Parnes.[5] The main purpose of the survey of the methods presented here, is to point out the basic differences in approaches.

In reviewing the recent literature on occupational requirements forecasts, it is intended to emphasize the methodological differences in approaches, rather than to report on the numerical results, mainly because such comparisons have been made elsewhere. For example, in the case of Canada, a comparison of the numerical results of studies by Watson and Butorac,[6] Ahamad,[7] and Meltz and Penz[8] has been reported by Skolnik and McMullen.[9] The format followed in this section is to provide a taxonomy of the methods used for occupational requirements forecasts and to review several recent studies illustrating the main approaches which are used widely.

The methods of forecasting occupational requirements can be classified into two groups. The first group consists of the methods based on (time-series) historical analysis of social and economic structure of the jurisdiction in question. The methods that are included in the second

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[1] L. J. Emmerij, and H. H. Thais, "Projecting Manpower Requirements by Occupation". In Lectures and Methodological Essays on Educational Planning, by the Organization for Economic Co-Operation and Development (Paris: Directorate for Scientific Affairs, 1966).

[2] R. G. Hollister, "The Economics of Manpower Forecasting", International Labour Review, edited by M. Blaug (Oxford: Pergamon Press, 1966).

[3] O. Mehmet, Methods of Forecasting Manpower Requirements with Special Reference to the Province of Ontario: Ontario Department of Labour and the Centre for Industrial Relations, University of Toronto, Toronto, 1965.

[4] N. M. Meltz, "The Applications and Limitations of Manpower Forecasting", Meeting Poverty, background paper for Conference on Poverty, Dec. 7-10, 1965 (Ottawa: Special Planning Secretariat, 1965).

[5] H. S. Parnes. Planning Education for Economic and Social Development. Lectures presented at the training course for Human Strategies, organized by the Directorate for Scientific Affairs, Sept. 3-28, 1962 (Paris: Organization for Economic Co-Operation and Development, 1968).

[6] C. Watson, and J. Butorac, Qualified Manpower in Ontario, 1961-1986; Volume 1: Determination and Projection of Basic Stock (Toronto: Ontario Institute for Studies in Education, 1968).

[7] B. Ahamad, A Projection of Manpower Requirements by Occupation in 1975: Canada and Its Regions (Ottawa: Department of Manpower and Immigration, 1970).

[8] N. M. Meltz, and P. G. Penz, Canada's Manpower Requirements in 1970 (Ottawa: Department of Manpower and Immigration, 1968).

[9] Skolnik and McMullen, op. cit., 1970.

group are: (i) the employers survey method, and (ii) the international comparisons method.

FIRST GROUP

Methods Based on the Historical Analysis of Social and Economic Structure of the Country

The methods falling into this group are based on the extrapolation of past trends of the statistics derived from the basic data on output and labour force at various levels of disaggregation. In a sense, therefore, all these methods could be classified as time-series models. The main distinction among these methods is due to the sequence of the computational steps involved and the level of aggregation of the data. There are two basic approaches that point to the distinction among these methods. In the first approach, the total labour force or employment for the country is projected and is later disaggregated into industry and occupation projections based on the historical trends. In the second approach, the occupational projections are made directly by industry, and are later aggregated to obtain the total occupational requirements for the country.

In the case of the first approach, there are two methods that can be used to project occupational requirements.

(1) Demographic Method

In this method, the total labour force is projected using the population projections and the projected labour force participation rates. By assuming a given unemployment rate, the total employment figures are obtained. The total employment is then broken down by industrial sectors, by applying the projected percentage distribution of total employment by industrial sectors to the total employment. From the sectoral employment, thus obtained, the sectoral occupational requirements are projected by applying the projected percentage occupational distribution by sector to the sectoral employment. By aggregating the sectoral occupational requirements, the total occupational requirements can be obtained. The projections of the percentage distribution of employment by sectors and the percentage occupational distributions within sectors are based on the extrapolation of the past trends.

This method was used by Meltz and Penz[1] to make projections of the occupational requirements in 1970 for Canada. Projections of the

[1] Meltz and Penz, op. cit., 1968.

Canadian labour force in 1970 were made by Denton, et al.[1] for the Economic Council of Canada. The size of the labour force in 1970 was obtained by applying the projected age-sex labour force participation rates for 1970 to the population projection by age-sex for 1970. In projecting the population by age and sex, the following steps were involved.

(a) Projection of the mortality rates by age and sex;

(b) Projection of the size and age-sex structure of gross immigration. Gross immigration was assumed to be 115,000 for 1964 and 125,000 for the subsequent years. The age-sex structure was determined on the basis of the observed distribution in 1954-1963;

(c) Projection of the size and age-sex structure of gross emigration. The size of gross emigration was assumed to be 75,000 each year. The age-sex structure was based on the U. S. immigration statistics on Canadian-born immigrants.

Based on the Economic Council of Canada projections of the labour force in 1970, and assuming a 3 per cent unemployment rate, Meltz and Penz[2] proceeded to project the distribution of employment among industries and occupations, together with the educational qualifications required to fill these jobs. The translation of projections of occupational requirements into projections of educational requirements is dealt with in the next section. The steps involved in obtaining the occupational requirements from the total employment, as described earlier involved: (i) projection of the distribution of the total employment by industrial sectors, and (ii) distribution of sectoral employment by occupation.

In their study, Meltz and Penz used the results of another study carried out by Drabble[3] for the Economic Council of Canada, in which he projected the breakdown of total employment by four major divisions of the economy: agriculture, public administration, community services and commercial non-agricultural sectors. Drabble projected the employment in agriculture by extrapolating the logarithmic trend of

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[1] F. T. Denton, Y. Kasahara, S. Ostry, Population and Labour Force Projections to 1970, Staff Study No. 1, Economic Council of Canada, December, 1964.

[2] Meltz and Penz, op. cit., 1968, p. 1.

[3] B. J. Drabble, Potential Output, 1946 to 1970, Staff Study No. 2, Economic Council of Canada (Ottawa: Queen's Printer, 1965).

agricultural employment during 1946-63 to 1970. The employment in public administration was projected by assuming that the potential output of all levels of governments combined (excluding defence) would rise at a rate slightly higher than the average for 1946-63 and that the output per man would remain constant at the 1957-63 average. The assumptions made in projecting employment in community services were that:

i) the rate of increase in potential output would be higher than in the first ten post-war years but slightly lower than in the 1956-63 period;
ii) the average hours of work per man would decline compared to the 1946-63 period; and
iii) output per man would remain constant at the 1963 level.

Employment in the commercial non-agricultural sectors was obtained as the residual.

Meltz and Penz proceeded to break down the employment in the commercial non-agricultural sector into twelve industry groups. Using the Labour Force Survey Data (employment) for the period 1946-63, for each industry sector, three alternative regression equations were fit to the data: (a) percentage employment in the industry as a function of time, (b) percentage employment as a function of time and the overall unemployment rate, and (c) percentage employment as a function of time, the unemployment rate and the squared value of the latter.[1] Also, in the estimation of the relationship of the industry employment percentages to the various combinations of the determinants, two alternative time periods (1946-63 and 1952-63) were analyzed. For each industry, from among the various combinations, one equation was selected for projection based on the following three criteria: (i) maximizing the correlation coeffient; (ii) obtaining a Durban-Watson statistic as close to 2 as possible; and (iii) ensuring the reasonableness of the projections on the basis of comparisons with the trend in the corresponding Census data and intuitive judgments.[2] Further, the selected projections were constrained to add up to 100 per cent.

The industry employment was then distributed by occupations using the decennial Census data for the years 1931, 1941, 1951 and 1961. For each industry, the trend of the percentage occupational distribution in the industry in the years 1931, 1941, 1951 and 1961 was extrapolated to obtain the percentage occupational distribution in

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[1] Meltz and Penz, op. cit., 1968, p. 7.

[2] Ibid., p. 13

1970. By applying the projected percentage occupational distribution to the employment in the industry, the occupational requirements for each industry were obtained. These were aggregated to obtain the total occupational requirements.

The basic assumptions which are implicit in this method are that: (i) the manpower requirements will change in accordance with the past trends; for example, in the Meltz and Penz study, it was assumed that the changes in the percentage industry structure of employment and the changes in the percentage occupation structure follow linear trends, and (ii) the occupation structure at any time is determined primarily by the technological structure rather than the supply conditions.

(2) Output-Productivity Method

Theoretically, an alternative approach to projecting the total employment by the demographic method, is to project the aggregate output (GNP) and productivity separately and then obtain the total employment by dividing the former by the latter. By following the same steps as in the preceding method, the occupational requirements can be obtained. One distinct advantage of this method over the demographic method is that the total employment projections need not be tied to a given unemployment rate in the target year. On the other hand, the total labour force and employment projections could be brought together to project the unemployment rate.

In practice, however, the output-productivity method is used mostly at the industry level, as for example, in the Mediterranean Regional Project of the O.E.C.D. and the Ahamad[1] projections for Canada. The methodology for projecting the occupational requirements in this case involves the following steps:

(a) projection of the aggregate output (GNP);
(b) projection of the distribution of the total output by industrial sectors;
(c) projection of the inverse sectoral labour productivity; and
(d) projection of the sectoral occupational distribution.

By multiplying (a), (b), (c) and (d) the sectoral occupational requirements can be obtained, the aggregate of which provides the total occupational requirements.

In mathematical terms, let E_{ij} be employment in occupation i and industry j, Y_j be total employment in industry j, and O_j be output in

[1] Ahamad, op. cit., 1970.

industry j and O be total output. Then:

$$E_{ij} = \left(\frac{E_{ij}}{Y_j}\right) \cdot \left(\frac{Y_j}{O_j}\right) \cdot \left(\frac{O_j}{O}\right) \cdot O$$

The first term in brackets to the right hand side of the equal sign represents the occupational distribution denoted by (d) above, and the second term, the inverse of the labour productivity in industry j, represents (c).

The most serious limitation of this method lies in the projection of sectoral productivity. The productivity problems appear at two levels: first, in forecasting the sectoral productivity and second, in estimating the future occupational structure within the sector. The second problem arises because it is only reasonable to expect that productivity changes will be related to changes in the occupational structure within a sector, because one of the factors affecting productivity changes is the shift in the nature of the technology employed. The lack of data necessary for estimating shifts in the occupational structure related to productivity changes makes this a formidable task.

This method was used to project occupational requirements in the Mediterranean Regional Project (MRP). The MRP was concerned with the forecasts for six countries: Italy, Greece, Portugal, Spain, Turkey and Yugoslavia.[1] In the case of Portugal, this method was rejected because of anomalies in the data which made this method statistically unfeasible. In projecting the aggregate output, its distribution by industrial sectors, and sectoral productivity, extensive use was made of the earlier works completed in each country. In the cases of Italy, Greece, Spain, Turkey and Yugoslavia, the economy was broken down into eight, nine, five and eight economic sectors respectively. In order to project the sectoral occupational requirements, the future occupational structure had to be forecasted. Shifts in the occupational structure within sectors were forecasted by extrapolating trends in structure from past periods. Generally, the occupational structure of the leading firm in each sector was used as a predictor of the average future pattern

[1] Hollister, op. cit., 1967.

in the sector. Also, use was made of international comparisons of occupational structures.

The second study where this method was used was Ahamad's projection of occupational requirements for Canada and its regions to 1975. At the national level, in the case of public administration, agriculture and fishing and trapping, the sectoral employment was projected directly by extrapolating the past employment trends. This was done mainly because of problems in projecting productivity, attributable to large fluctuations in the recorded output for these sectors. At the regional level, employment was projected directly, rather than by projecting separately sectoral output and sectoral productivity. This was done mainly because the sectoral output data was not available by regions. The regional employment projections by industrial sectors were made on the basis of extrapolation of the historical trends in the employment data, along with subjective judgment. In general, the author acknowledged that they are "... based on a great deal of subjective assessment and are obviously limited by the uncertainty in our judgment".[1] The projection of the occupational distribution within each sector, at the national level, was based on the extrapolation of the trends through the 1941, 1951, and 1961 Census points. At the regional level, the occupational distribution within each sector was available only from the 1961 Census. The projections of the occupational distribution within each sector for the period 1961-75 were made by applying the national trends for each sector to the regional 1961 occupational distribution for each sector. However, this was not done entirely mechanically, but adjustments were made on the basis of judgment in each case.

In an important variation of the second approach, where the occupational forecasts are made directly by industry, the following method can be used.

(3) Occupational Coefficients Method[2]

The rationale for this method is based on the relationship between output of the industry and the number of people in a given occupa-

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[1] Ahamad, op. cit., 1970, p. 5.

[2] Proulx estimated occupational coefficients for sixty-four occupations and forty-three industry groupings for Nova Scotia, based on 1961 Census data. He did not, however, attempt to make projections of the coefficients or of manpower requirements. For detail, see Pierre-Paul Proulx, "Manpower Coefficients and the Forecasting of Manpower Requirements", mimeographed (unpublished), Departement des Sciences Economiques, Universite de Montreal, April 1970.

tional category in that industry. The ratio of the number of people employed in a given occupation to the output of the industry is often referred to as the 'occupational coefficient' for the industry. Precisely, the number of people in occupation 'a' in industrial sector 'b' required per million dollar of output is defined as the occupational coefficient for occupation 'a' in sector 'b'. The steps involved in obtaining the occupational requirements following this approach are the following:

(a) projection of the sectoral output;
(b) projection of the occupational coefficients for each sector;
(c) multiplying (a) by (b) to obtain sectoral occupational requirements;
(d) aggregation of the sectoral occupational requirements to obtain the total occupational requirements for the economy.

In both the demographic and the output-productivity methods, the sectoral occupational requirements are obtained by distributing the sectoral employment into employment by occupations, using the percentage occupational distributions. One of the advantages of using occupational coefficients is that it may be less sensitive to cyclical fluctuations in the state of the economy. The number of engineers employed per ton of steel output is not affected by the general absorption and releasing of unskilled labour in the economy to the same extent as is the ratio of engineers to total employment. Relating occupational projections by industry directly to industrial output is more in keeping with the concept of manpower requirements than is the occupational distribution approach.

SECOND GROUP

(1) Employers Survey Method

Using this method manpower requirements are estimated by asking employers how much of each kind of labour they expect to hire in the next few years. By summing the demand of all the employers and subtracting from it the estimated deaths and retirements (and turnover), the net required manpower inflows for the target year are projected.

Implicit in this method is the assumption that employers themselves make such forecasts. The aggregation of the estimates of the individual employers to obtain the future manpower requirements is the main limitation of this method. In the employers survey, questions about the production levels or expected rates of growth of output are rarely

asked. Even if the growth rates for industrial output are specified in the questionnaire, where there may be more than one establishment in any industrial sector (for which the growth rates have been specified), an employer cannot make a reasonably acceptable forecast of his manpower requirements without definite knowledge about his future market share. Thus, the process of aggregation may involve double counting. Further, this method has no provisions for the demand generated by new firms that may come into existence after the initial date. There is also the danger that the employers may overstate their requirements to get government support for expanding supplies.

In spite of the above limitations, this method has been used extensively in the United Kingdom to make forecasts of scientific manpower requirements. The Committee on Scientific Manpower under the chairmanship of Sir Solly Zukerman made three three-year forecasts in 1956, 1959 and 1962. The Committee on Manpower Resources for Science and Technology, which succeeded the Zukerman Committee in 1965, continued to use this method for projecting the requirements of engineers, technologists and scientists.

Perhaps as a short-term forecasting method, it could be regarded as an important tool to gain information about labour market conditions in the near future. However, if the purpose of the forecasts is to facilitate a type of manpower planning which requires long-term forecasts, the utility of this method is practically nil. As Harbison and Myers argue, forecasts made by individual establishments are essentially part of an assessment of the present situation rather than a practical means of making long-run forecasts.[1] Employer surveys may be useful for obtaining qualitative information and as an aid for very short-term forecasts for a specific industry where other information is not available.

(2) The International Comparisons Method

By this method the future manpower requirements for a given country are forecasted mainly on the basis of historical and current manpower data from other countries. This method has been used and recommended in the case of countries at a relatively early stage of economic development. The usual procedure is to forecast the occupational structure of a developing country, using the observed occupational structure of another economy. For example, Puerto Rico's 1957

[1] F. Harbison, and C. A. Myers, Education, Manpower and Economic Growth: Strategies of Human Resource Development, (New York: McGraw Hill, 1964) p. 196.

forecasts of the distribution of the labour force by occupation and education up to 1975, were made using the educational attainments and occupational categories of the American labour force in 1950, as the target for the Puerto Rico's economy in 1975.[1] One reason for using this approach is that developing countries usually have very poor historical data. However extrapolations of the past data to forecast the future would be misleading in view of the major structural transformations of the economy and the society to which the policies in developing countries are often committed.

The major limitations of this method are that, first, it ignores a variety of cultural, institutional, and geographical differences among countries at similar levels of economic development. Second, it neglects the time element in the historical process, as for example, when proper emphasis is not given to the environmental differences between a western nation of the nineteenth century and an industrializing nation with the same per capita income in the middle of the twentieth century. On the validity of the Harbison-Myers Composite Index of Levels of Human Resource Development, which has been used often, Blaug comments, "it deserves its fame for it embodies virtually every mistake that it is possible to make in international comparisons of income and education".[2]

B. Forecasting Attrition Rates and Required Manpower Inflows

The prime purpose of forecasting manpower requirements is to estimate the number of additional workers of a particular skill category who will be required in the future to achieve defined social and economic targets. This is often referred to as the required manpower inflows of a particular skill category. During any year t for any occupation x, the required inflow can be described as the gross requirement for occupation x in year t less the stock of occupation x at the beginning of year t-1, plus attrition to the stock of occupation x during year t-1. The underlying theory and the methods of forecasting gross occupational requirements have been dealt with in the preceding section. In order to obtain the required manpower inflows of a particular skill category during the forecasting period, the additional information necessary is the magnitude of the net attrition, (i) of the base year

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[1] Puerto Rico, Committee on Human Resources, Puerto Rico's Manpower Needs and Supply (San Juan, Puerto Rico, 1959).

[2] M. Blaug, An Introduction to the Economics of Education, (London: The Penguin Press, 1970) p. 68.

stock during the forecasting period, and (ii) of the entrants to the labour force in that occupational category during the forecasting period.

The net attrition for any occupational category consists of the following three factors: death and retirement, inter-occupational mobility, net immigration and inter-regional migration.

1. Death and Retirement

In order to compute the attrition due to death and retirement, the data required for each occupational category are:

i) the stock by sex and age at the beginning of the forecasting period;
ii) for each year of the projection period, the number of new entrants by age and sex; and
iii) age-sex specific annual death and retirement rates for each occupational category.

By multiplying (iii) by (i) and by (ii), the total attrition due to death and retirement can be obtained.

The method commonly used for calculating the occupation specific attrition rate due to death and retirement assumes that age-sex specific attrition rates are the same for all occupations. In other words, it is assumed that attrition due to death and retirement is dependent only on age and sex, not on occupation. This assumption is made out of necessity, because there is little or no data available on death and retirement rates by occupational category. Meltz and Penz[1] have used the same approach in their forecasts of attrition due to death and retirement.

2. Inter-Occupational Mobility

There is not enough information on the matrix of movements between occupations to enable us to build an inter-occupational mobility component into the manpower forecasting models. Consequently, in most studies on manpower forecasts, the net inter-occupational mobility is assumed to be zero.[2] However, when dealing with specific occupations, for example, engineers or physicians, it may be possible to give some consideration to occupational mobility.

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[1] Meltz and Penz, op. cit., 1968.

[2] Ibid.

3. Net Immigration and Inter-Regional Migration

At the regional level, the attrition in an occupation category is determined by two factors, the net immigration, and the inter-regional migration. Numerically, the attrition in an occupational category due to net immigration during a year is defined as the difference between the number of immigrants joining the occupation and the emigrants leaving the occupation. Similarly, the attrition due to inter-regional migration during a year is defined as the difference between the number of persons of the specific occupation category who move to other regions within the country, and the number of persons joining the specific occupation category who arrive in the region from other regions within the country.

Even if the historical statistics were available, immigration is difficult to project since it depends upon fluctuating labour market conditions in both the receiving and donor countries and is subject to government policies. In the case of Canada, since it is the federal and not the provincial government that has major control over immigration policies, the task of projecting immigration at the regional level becomes even more complicated.

In Canada, the only data available on immigration is on "intended occupation" of immigrants, and there is little information as to whether the individual immigrant possessed qualifications acceptable to the relevant professional association or even for the intended field of work. Also, there is no information on whether the realized occupation was the same as the intended one. The nature of data on emigration by occupation is even worse. Consequently, it is not only difficult to compute and analyse historical statistics on attrition in each occupation category due to net immigration, but impossible to accurately forecast the future trends. The lack of proper data on immigration and emigration poses a serious problem, even when it may be assumed that immigration policy is designed to resolve imbalances in the labour market. It should be noted that incorrectly anticipated immigration can have a disastrous effect, turning even a potential labour shortage into a surplus. The net growth in requirements for a particular occupation may have been projected with great accuracy, but there may be an unexpectedly large number of immigrants competing with the new graduates for jobs. For this reason, immigration policy must be considered an integral part of manpower planning.

In the case of inter-provincial migration by occupation, adequate data do not exist for making projections. If it is assumed that inter-provincial migration is responsive to short-term fluctuations in labour

market conditions, then knowledge of net migration is more crucial for our purpose than knowledge of inter-provincial migration.

II. FORECASTING MANPOWER SUPPLY

A. Additions to Manpower Supply

In the context of a manpower information system, the rationale for forecasting the additions to manpower supply is to present a comparison between potential supply and forecasted requirements for a particular category. In general, the total potential additions to the supply of manpower of any particular category, at any time, in any jurisdiction, come from the following sources:

i) the formal education sector, or apprenticeship and other training programmes;
ii) the net immigration and inter-jurisdictional migration; and
iii) the inter-occupational mobility.

In a jursisdiction where the supply from the formal education sector constitutes a major component of the total potential supply, it is important that consideration be given to the factors affecting the supply from this source. Especially in the case of trained manpower the potential supply from the formal education sector at any time is constrained by the behaviour of the various decision-makers a few years earlier. One of the vital elements of the supply sub-system of the manpower information system is thus the provision of information about the number of students, apprentices, and trainees in the pipeline in the various programmes.

For accounting purposes the component of the total potential additions to supply contributed by sources (ii) and (iii), that is, net immigration and inter-jurisdictional migration, and inter-occupational mobility can be separated into two groups:

(a) the first group consisting of all immigrants and migrants who join the labour force directly, and the members of the labour force who change their occupation without going back to the formal education sector or into specific training programmes, and
(b) the second group consisting of all immigrants and migrants who enter formal education or programmes of retraining with a view to changing their occupation, immediately after arrival at their destination, as well as other persons who enter into education or training in order to change their occupations.

The underlying concepts and the problems of forecasting the magnitude of the potential supply emanating from group (a) have been dealt with in the previous section. For the purposes of forecasting the total potential supply, group (b) is considered to be a part of the potential supply from the formal education sector. The main purpose of the discussion here is to review the underlying concepts and the methods used for forecasting the manpower supply from the formal education sector.

B. State of the Art

The present state of the art reveals a dichotomy between the explanatory models of enrollment demand and models underlying enrollment forecasts. In Canada and United States, there have been at least eight studies in which an attempt was made to account for variations in some measure of participation in education in terms of economic variables (Campbell and Siegel,[1] Crean,[2] Duncan,[3] Galper and Dunn,[4] Handa,[5] Hoenack,[6] Radner and Miller,[7] and Schaafsma[8]). Only in one was an attempt made to use the demand model to generate enrollment forecasts. On the other hand, the forecasting models made no attempt to explain trends in enrollment variables in terms of socio-economic

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[1] R. Campbell, and B. N. Siegel, "The Demand for Higher Education in the U.S., 1919-1964", American Economic Review (June, 1967), 482-94.

[2] John F. Crean, "Foregone Earning and the Demand for Education: Some Empirical Evidence", Groupe de recherche sur l'economie du Secteur Public (Quebec, 1971).

[3] B. Duncan, "Dropouts and Unemployed", Journal of Political Economy (April, 1965), 121-135.

[4] H. Galper, and R. M. Dunn, Jr., "A Short-Run Demand Function for Higher Education in the U.S.", Journal of Political Economy, LXXVII, No. 4, Part II (July - August, 1969), 765-777.

[5] M. L. Handa, "Towards a Rational Educational Policy: An Econometric Analysis of Ontario (Canada) 1959-65 with Tests 1966-68 and Projections, 1969-75 (Toronto: The Ontario Institute for Studies in Education), Monograph Series No. 12, 1972.

[6] S. A. Hoenack, "The Efficient Application of Subsidies to College Students", American Economic Review, LXI, No. 3 (June 1971), 302-11.

[7] R. Radner, and L. S. Miller, "Demand and Supply in U.S. Higher Education: A Progress Report", American Economic Review, LX. No. 2 (May 1970), 326-34.

[8] J. Schaafsma, "The Demand for Higher Education". (Toronto: Institute for Quantitative Analysis of Social and Economic Policy).

variables or income. In nearly all cases enrollment variables were extrapolated simply as a function of time. The only influencing factor which in some cases was considered was admission standards (Lapp,[1] Holland, et al.[2]). The enrollment variables which usually are considered are age-group participation rates or the transition rates roughly estimated from stock data, for example, relating second year enrollment in a given year to first year enrollment of the year before. However, the forecasting models can achieve a consistently high degree of accuracy, for example, the work of Watson and Quazi.[3]

A comprehensive analysis of the eight studies relating to the explanatory models of the demand for education has been done by Handa and Skolnik.[4] They point out that, "in spite of rather simple methodology, many of these projections have demonstrated a consistently high degree of accuracy".[5] The accuracy obtained by simple extrapolation models suggests that the desire to make enrollment projections is not a justifiable motivation for developing explanatory models of the demand for education. However, the main value of the explanatory models lies in their importance for providing valuable information regarding possible alternatives to aid in the formulation of policies for the educational sector. Unfortunately, "the existing studies are not sufficiently policy-oriented".[6] The other point that may deserve some mention is that little work has been done so far at a disaggregated level, either by socio-economic background or by field of study. "Yet possibly the most important reason for analyzing patterns of the demand for education is to ascertain the extent to which students' choices, among various

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[1] P. A. Lapp, "Undergraduate Engineering Enrollment Projections for Ontario, 1970-80", Committee of Presidents of Universities of Ontario, Report No. 70-1 (October 1970).

[2] J. Holland, S. Quazi, F. Siddiqui, M. Skolnik, Manpower Forecasting and Educational Policy. A report prepared for the Commission on Post-Secondary Education in Ontario (Toronto: Queen's Printers, 1972).

[3] C. Watson and S. Quazi, "Ontario School and University Enrollment Projections to 1981-82", Enrollment Projections Series No. 1 (Toronto: OISE, 1966).

[4] M. L. Handa, and M. Skolnik, "Empirical Analysis of the Demand for Education in Canada", Canadian Higher Education in the Seventies, ed. by Sylvia Ostry (Ottawa: Economic Council of Canada, 1972), pp. 5-44.

[5] Ibid., p. 23.

[6] Ibid., p. 39.

fields of study, are influenced by perceptions of the employment opportunities in the corresponding occupations".[1] When major structural changes in the educational system are not envisaged and the objective is to forecast potential supplies of qualified manpower, particularly in disaggregated form, then at present the odds are heavily in favour of using simple extrapolation models – especially when there are no adequate theories of enrollment demand and occupational choice.

The fundamental assumption underlying forecasting methods based on extrapolation of past statistical trends is that there will be no radical changes in the structure of the educational system, in educational policy or in institutional behaviour. Perhaps the most important single factor responsible for lack of innovation in the methodology of enrollment forecasting has been the lack of adequate data. In Canada, as in most other nations, there exist only unidimensional (stock) data on enrollment, except for occasional small longitudinal surveys. Stock data pertain to the position (location and/or status) of a group of students at one point in time. They provide no information on the position of members of that group at earlier points in time. Because of the limitations of the data, methodologies have been restricted to two basic approaches.

In the first, which might perhaps be called the participation rate method, stock data on enrollment are related to the population of an age-group. In the second, if stock data are available by year and programme (for example, first year university Arts and Science, second year, etc.) flows through the system are estimated by comparing the stock of second year students in a given programme in a given year to stock of first year students in that programme the year before, and the stock of this year's third year students to that of last year's second year students, and so on. The second approach might well be defined as flow models based on stock data. In both, the forecasting involves two basic tasks:

(a) Analyzing historical trends, and
(b) producing extrapolations of perceived trands in those statistics.

The literature on methods for enrollment forecasting sometimes lists a large number of methods. Lins,[2] for example, presents six or seven

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[1] Ibid., p. 38.

[2] L. J. Lins, Methodology of Enrollment Projections for Colleges and Universities (Washington, D.C.: American Association of Collegiate Registrars and Admission Officers, 1960).

'methods', but all, essentially, fall into one of the above two categories. The distinction is claimed on the basis of the technique used for extrapolating the historical trends. For example, the 'free hand method' is one in which the trends are extrapolated graphically by free hand. A great number of potential variants of these two basic approaches are possible, depending upon the nature of the data available. For example, in computing the participation rates used in the first approach, total enrollment or enrollment by year of study and programme might be related to a population age-group, and the participation rates then be extrapolated simply as a function of time, graphically, or through a regression equation of varying degrees of complexity. In the second approach, one might relate enrollment in the first year of university to a weighted average of the secondary school enrollment of one, two, and three years earlier. Again the trends might be extrapolated solely as a function of time or of time plus some socio-economic variables.

The 'flow model based on individual student flows' is another possible method. However, these were not developed primarily for making enrollment projections but to provide an analytical tool for managing educational systems. In Canada, they are still theoretical, because the data needed for their operations do not exist. They require year-to-year statistics on each student in the educational system. Since the students are identified individually, it is possible to observe their flow through the system. The main advantage of such models is their capacity to analyze the performance of the system and permit simulation of the effects of contemplated changes of policy.

While there have been a number of studies giving forecasts of enrollment and graduates for the post-secondary education sector, there have been few attempts to forecast additions to labour supply resulting from apprenticeship and other training programmes.[1]

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[1] For a survey of some recent post-secondary enrollment forecasting studies in Canada, see J. Holland, S. Quazi, F. Siddiqui, M. Skolnik, Manpower Forecasting and Educational Policy. A report prepared for the Commission on Post-Secondary Education in Ontario (Toronto: Queen's Printer, 1972).

For Projections of additions to supply from apprenticeship and other training programmes in Ontario, see:

Bruce MacDonald, Technological Change and Manpower Requirements to 1975: Ontario's Mechanical Construction Industry. Research Branch, Ontario Ministry of Labour, February 1971.

Farid Siddiqui, Projections of Labour Supply for Selected Construction Trades: Ontario and Kitchener/Georgian Bay Region. Research Branch, Ontario Ministry of Labour, June 1974. (Mimeo.).

CHAPTER II

METHODOLOGY AND DATA REQUIREMENTS FOR MAKING MANPOWER PROJECTIONS

The preceding chapter included a survey of the methods for making manpower projections. The discussion in this chapter centres on the most appropriate methodology and data requirements for forecasting manpower requirements and supply.

PREFERRED METHODOLOGY AND THE DATA REQUIREMENTS FOR ITS IMPLEMENTATION

A. Forecasting Required Manpower Inflows by Occupational Classes

The task of forecasting required manpower inflows by occupational classes using the output/occupational relationship consists of the following steps:

(a) Forecast gross occupational requirements;

(b) Forecast attrition of base year stock and of new entrants who join the labour force during the forecasting period, and derive the required manpower inflows by occupational classes.

The proposed methodology for forecasting each of the above components is as follows:

(a) Forecast Gross Occupational Requirements

The method suggested for forecasting the gross occupational requirements is the occupational coefficients method, which can be described by the following relationship:

$$G^t = C^t \cdot X^t$$

where

G^t is the (m x 1) vector of gross manpower requirements by occupation in year t.

C^t is the (m x n) order matrix of occupational coefficients by industry. Each element represents the number of persons in a given occupation required in a particular industry per million dollars of output in constant dollars in year t.

X^t is the (n x 1) vector representing output by industry in year t.

In order to project occupational requirements by this method, it is

necessary to project (i) the vector of output by industry, and (ii) the matrix of occupational coefficients by industry.

Before proceeding to discuss the methods for projecting these components, it may be desirable to clarify what is meant by an industry. In the Standard Industrial Classification (SIC), the term 'industry' is used in its broadest sense to include all economic activity from the primary industries such as agriculture and forestry to those concerned with rendering of services. Statistics Canada, which is the main source of data, in its Standard Industrial Classification Manual (Revised 1970) defines an industry "as a group of operating units e.g. companies or establishments engaged in the same or a similar kind of economic activity, e.g., logging camps, coal mines, clothing factories, department stores, laundries".[1] At the most aggregated level the industries are classified into a dozen divisions, and at the most disaggregated level (3 digit code) there are 276 industries. The objective of the SIC is to provide a common framework so that comparable data can be secured from different statistical sources.

i) Projecting Output by Industry

In the case of projecting output by industry, one conceivably could proceed to forecast the growth and output of each industry in the economy simply on the basis of its past performance. The fact remains, however, that the growth of any one industry is related to the growth of other industries as well. For example, the output of industry A might be an input in industry B. Consequently, the growth of industry B is constrained by the performance of industry A. The methods dealing with the projections of the output of an industry, ideally should take into account these inter-dependencies among the various industrial sectors in the economy. The input-output technique developed by W. W. Leontief[2] is based on these types of inter-industry relationships among the various sectors in the economy. The output of any sector x may either be bought by firms in any of the other sectors, or by the economic agents outside the business system, such as consumers, the government, or foreign firms. The former part is referred to as the intermediate demand for the products of sector x, and the latter groups are the final demand. The flow of goods and services among the various sectors of the economy relating to the intermediate demand constitute

[1] Statistics Canada, Standard Industrial Classification Manual, Revised 1970, p. 7.

[2] Wassily Leontief, The Structure of American Economy, 1919-1939 (2nd. ed., revised, New York: Oxford University Press, 1951).

the input coefficients of the input-output tables. The input-output theory deals primarily with the question of what can be said about the total output of each sector, given final demand. Mathematically, let x_j represent the total output of sector j, and x_{ij} the output of sector i sold to sector j, then we define a_{ij} as follows:

$$a_{ij} = \frac{x_{ij}}{x_j} \quad (i, j = 1,. . .n)$$

where a_{ij} is the (i, j)th element of the input-output table or in other words the (i, j)th input coefficient, denoting the input of sector i to sector j per unit of output of sector j.

If the final demand for the products of sector i is represented by f_i, then the total output is the sum of the intermediate demand and the final demand for the output of sector i, can be expressed by the following relationships:

$$x_i = \sum_{j=1}^{n} x_{ij} + f_i$$

$$= \sum_{j=1}^{n} a_{ij} x_j + f_i$$

$$x_i - \sum_{j=1}^{n} a_{ij} x_j = f_i$$

where i = 1,. . . . . .,n
and j = 1,. . . . . .,n

The above set of equations can be written as:

$$(1 - a_{11})x_1 - a_{12}x_2 - \ldots\ldots\ldots - a_{1n}x_n = f_1$$

$$a_{21}x_1 - (1 - a_{22})x_2 - \ldots\ldots\ldots - a_{2n}x_n = f_2$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$a_{n1}x_1 - a_{n2}x_2 - \ldots\ldots\ldots - (1 - a_{nn})x_n = f_n$$

in matrix notation this can be expressed as:

$$(I - A)X = F$$

where

I – is the (n x n) order unit matrix

$A = [a_{ij}]$ – is the (n x n) order matrix of input coefficients

$X = [x_i]$ –is the (n x 1) order vector of total output by sector i

$F = [f_i]$ –is the (n x 1) order vector of final demand by sector i,

Solving the equation for X, we get

$$X = (I - A)^{-1}F$$

Thus, when the input coefficients matrix and the sectoral final demand estimates are available, the total output by sector can be estimated by using the above relationship. The task of forecasting the sectoral output requires the projections of the sectoral final demand for each sector for each year of the projection period and the projection of input-output coefficients for the economy. The classical assumption of the input-output theory has been to assume the input coefficients a_{ij} to be constant over the projection period.[1] However, if the input-output tables were

[1] Ibid., p. 169.

available for a number of years on a comparable basis over time, then one could treat input-output coefficients as another forecasted variable.

Since the final demand is composed of a set of heterogenous components, that is (i) export, (ii) private consumption, (iii) consumption by government, (iv) gross domestic fixed capital formulation by enterprises, (v) gross domestic fixed capital formation by government, and (vi) changes in inventories and in work-in-progress; it seems advisable that the approach for forecasting the final demand must take into account the variations in the individual components rather than being merely a forecast of the aggregate final demand based on any single historical time series.

Once the total output estimates by industry have been obtained, the feasibility of achieving the forecasted levels of output by sector can be tested by investigating the present level of plant capacity utilization for each industry, disaggregated at the establishment level, and the availability of additional capital required to achieve the forecasted production targets.

Thus, the data requirement for projecting the output using the above method are:

1. Input-output table, representing the flow of goods and services among the various sectors of the economy giving input-output coefficients. The tables should be available for a number of years constructed at regular intervals using comparable definitions over time.
2. Statistics related to the components constituting the final demand.
3. Statistics on plant capacity utilization, level of technical sophistication, and size of each establishment for every industrial subsector in the economy.

ii) Projecting the Occupational Coefficients by Industry

An occupational coefficient for an industry represents the number of persons required in a given occupation in the industry per million dollars of output in constant dollars. The occupational coefficients for an industry at any point in time reflect the supply conditions, the level of sophistication of the technology employed, the number, and the size of the various establishments as well as the extent of plant capacity utilization. The changes in the occupational coefficients over time, therefore, should correspond to changes in the supply conditions, changes in the level of sophistication of the technology, and changes in the number, size, and capacity utilization rates in each of the establishments in the industry.

It is important to emphasize that even at the lowest level of industrial classification an industry is in fact an aggregate of a number of smaller units, that is, establishments. In an empirical study dealing with two Japanese industries, R. Komiya and T. Uchida have shown, "that the size of the establishment is one of the most important factors which cause differences in the labour co-efficients among establishments: the (labour) coefficients for smaller establishments are larger than the ones for larger establishments".[1] The finding is important in the sense that it points out that a change in the occupational coefficients over time could be caused simply by a change in the size-distribution of the establishments.

Ignoring the question of the effects of economies of scale on occupational coefficients, economists have traditionally attributed changes in occupational coefficients over time to changes in supply conditions and to changes in technology.[2] Technology has remained an amorphous entity not rigorously defined operationally. The main argument against using presently observed occupational coefficients for manpower forecasting is that they may be determined primarily by the skill supply conditions which are unique to the particular time and place.[3] There has not been sufficient empirical research to assess the extent to which the coefficients at a given time reflect unique supply conditions rather than technology. The problem of separating the supply effects from the technological effects on occupational coefficients remains a serious one, as emphasized in the discussions of the substitution problem in Chapter 1.

The difficulty of assessing the role of supply effects is due mainly to identification problems associated with available time series data on occupational distribution. In view of these problems, Hollister has suggested the necessity of cross-section analysis. After stating that the effects of the economies of scale on occupational coefficients are ignored, he argues that, "if it is assumed that technological knowledge is a free international good and that, therefore, at any point in time differences among countries attributable to differences in technological knowledge, in the purest sense, are limited and negligible, then inter-

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1 R. Komiya, and T. Uchida, "The Labour Coefficient and the Size of Establishment in Two Japanese Industries", ed. by Tibor Barna, in Structural Interdependence and Economic Development (MacMillan and Co., 1963), p. 274.

2 R. G. Hollister, "The Economics of Manpower Forecasting", International Labour Review, Vol. 89, No. 4 (April, 1964) pp. 371-97.

3 Ibid., p. 381.

national comparisons of occupational coefficients will provide the best information on the response of these coefficients to supply effects – the supply effects may be identified".[1]

The rationality of Hollister's arguments hinges on the validity of his two assumptions, that is, (i) ignoring the effects of the economies of scale, and (ii) that the differences in the technological knowledge and capacity for application of technological knowledge are limited and negligible. The empirical findings of Komiya and Uchida tend to contradict the first assumption. About the second assumption, it is not clear what Hollister means by technical knowledge. If it refers to the availability of the technical literature, then Hollister's assumption may be valid. However, if the technological knowledge refers to the methods of production, capital intensity, working conditions and so on, then the existence of the differences, even within a country, among establishments in an industry makes the validity of his second assumption very doubtful. Komiya and Uchida observed that, "there seems to exist, particularly in Japan, considerable differences in input coefficients between large and small scale establishments in an industry because of what is called the dual structure of the Japanese economy. The term dual structure refers to the fact that methods of production, capital intensity, managerial organization, working conditions, wage rates and so on, differ very much between firms or plants of different sizes".[2]

The purpose of the preceding comments is not to minimize or ignore the effects of changes in the supply conditions on the occupational coefficients, but to point out their relative position with respect to other factors. The establishments in an industry constitute a heterogenous group with respect to methods of production, capital intensity, managerial organization, working conditions and so on. Perhaps, it could also be argued that the possibilities for substitution are also constrained by these specific conditions in the individual establishments in an industry at any point in time. Thus, in order to study and forecast the changes in the occupational coefficients for an industry over time, changes in the occupational coefficients should be related to changes in the types of individual establishments in that industry.

Theoretically, the data requirements for estimating the occupational coefficients at any point in time are:

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[1] Ibid., p. 384.

[2] Komiya and Uchida, op. cit., p. 265.

i) employment by occupation, and by sex if possible, for each industry; and
ii) output by industry.

Ideally, to forecast occupational coefficients over time would require additionally time series data for:

i) employment by occupation, and by sex if possible, for each establishment in the industry;
ii) output for each establishment in the industry; and
iii) statistics related to plant utilization factors, level of technological sophistication, and size for each establishment in the industry.

(b) Forecasting Attrition and Required Manpower Inflows by Occupational Classes.

The underlying concepts dealing with the causes and types of attrition have been dealt with in detail in Chapter I. To summarize, there are three types of attrition:

i) due to death and retirement;
ii) due to inter-occupational mobility; and
iii) due to net immigration and inter-provincial migration.

Also, there are two different stocks of manpower which are affected by attrition:

- the stock existing at the beginning of the projection period; and
- the stock of new entrants to the labour force during the projection period.

The forecasting of attrition by occupation due to death and retirement should be based on occupation specific attrition rates due to death and retirement by age and sex. The data required are on death and retirement by occupation, age and sex.

To project the required manpower inflows by occupation classes, the projected attrition rates can be applied to the two different stocks of manpower. The attrition to the manpower stock present at the beginning of the projection period can be obtained by simply multiplying the stock in question by the attrition rates. However, to project the

attrition to the stock of new entrants, one must make some assumptions about the number who will enter the labour force, and the age structure and sex of the new entrants.

The two extreme assumptions which can be made about the number of new entrants to the labour force of any occupational class are:

i) that the number of new entrants during each year of the projection period is zero; and
ii) that the number of new entrants to the labour force in year t is equal to the gross occupational requirements for year t less the stock at the end of year t-1, that is, the market for each occupation is in balance every year.

Between these two extreme possibilities, there are, of course, a number of alternative assumptions that can be considered, such as those involving behavioural models of interacting supply and demand functions. The question of the age structure of the new entrants can be resolved either by assuming a given age structure or by projecting the age structure of new entrants based on past data. The projections of the age structure can be made by relating changes over time in the age structure of new entrants to the labour force for each occupational class to the changing supply and demand conditions in the labour market.

B. Forecasting Manpower Supplies

The sources of total potential supplies of manpower of any particular category at a given time in any jurisdiction come from the following sources:

i) the formal education sector, and apprenticeship and other training programmes;
ii) net immigration and inter-provincial migration; and
iii) inter-occupational mobility.

As pointed out earlier in Chapter 1, for accounting purposes, the component of the total potential supplies contributed by sources (ii) and (iii) can be separated into two groups:

(a) the group consisting of all immigrants and migrants who join the labour force directly, and the members of the labour force who

change their occupation without going back to the formal education sector or into re-training programmes;

(b) the group consisting of all immigrants and migrants who enter the formal education sector or specific programmes for retraining, and members of the labour force who enter the formal education sector or re-training programmes with a view to changing their occupation.

The component of the total potential supply emanating from group (b) can be considered to be a part of the potential supplies from the formal education and training sector.

The component of the total potential supply emanating from group (a) has two components:

i) consisting of all immigrants and migrants who join the labour force directly; and

ii) members of the labour force who change their occupation without going back to the formal education or training sector.

Component (ii) represents the scope of inter-occupational mobility. Theoretically, component (i) could be included as part of net attrition. However, it may be appropriate to consider component (i) separately when dealing with occupations where immigration may constitute a serious threat to job seekers from within a region.

Given this framework, the significant distinction from the point of view of forecasting manpower supplies is between the supply from the formal education and training sector and that from immigration and inter-regional migration, leaving aside component (ii) above.

In the case of the supplies from the formal education sector, especially when the length of the forecasting period is short or medium-term, the potential supply of a particular skill category is constrained by the magnitude of the existing enrollment in the relevant programmes. For example, in medicine the length of the training period is five years, the magnitude of the potential supply from domestic (provincial) sources in the year 1976 is limited by the number of students who were enrolled in the course in the year 1971. The information needed on supply from the educational system would include data on the existing enrollment by year of study in the various programmes corresponding to a particular skill category. Ideally, the methodology for forecasting manpower supply from the formal education sector

should take into account the factors affecting the flow of students through various programmes in the educational system and the factors affecting the choice of a particular programme. If the prime purpose is to forecast the magnitude of the potential supply from the formal education sector, then the extrapolation models using the statistics on student flows through the educational system may suffice for the purposes of manpower forecasting. However, it would be advisable that the extrapolation of the variables should not be carried out mechanically. It is recommended that in the extrapolation, extensive use should be made of the trends in the factors which appear to affect the process.

Ideally, the statistics on the student flows through the educational system should be compiled from year to year on the individual students in the educational system. It may be difficult to justify the collection of this data primarily for the purposes of enrollment forecasting. However, the utility of these statistics for the purposes of managing the educational and training systems would certainly provide a strong justification for their collection.

With regard to immigration and migration, perhaps it could be argued that voluntary migration of individuals and households occurs because of short and medium-term fluctuations in the labour market conditions at the origin and destination of the migration. In the case of immigration, however, the motivating factors may be the differences in the national wealth, freedom in the choice of life style, and political conditions, etc., between the receiving and the sending countries. Thus, in the context of Canada, it would be safe to assume that the pool of potential immigrants to Canada is almost unlimited for most skill categories. The constraint operating, therefore, is not the number who are willing to immigrate to Canada, but the numbers which can be absorbed or are allowed to enter the Canadian economy. However, the effectiveness of immigration policy as a regulatory device for the resolution of perceived shortages and/or surpluses of specific skills is constrained by the uncertain relationship between the intended occupations of immigrants and the actual occupation of employment in the Ontario labour market, which depends on the acceptability of their skills by domestic professional associations, unions and employers. Thus, the task of projecting manpower supplies by occupational classes resulting from immigration to Ontario consists of the following steps:

(a) projection of the numbers of immigrants to Canada;
(b) projection of the number of immigrants settling in Ontario;
(c) projecting the distribution of immigrants by intended occupations; and

(d) projection of the relationship between intended occupations and the actual occupation of employment of the immigrants by their ethnic background.

The preceding discussion outlines a methodology for forecasting manpower requirements and supplies. This information on forecasted manpower requirements and supplies can also be used as an input along with data on earnings for new graduates, unemployment and unfilled job vacancies to carry out further studies on the labour market for specific occupations. Though data on unemployed by detailed occupational classifications for the province are not available at the present time, some data on earnings for new graduates and unfilled job vacancies for selected occupation groups are available.[1] These studies can be used as a basis for projecting expected wages for new entrants into an occupation as a function of the projected requirements and supplies. Also in retrospect by analyzing the forecasts e.g. comparing the forecast for 1974 to the actual data for 1974, such studies can provide valuable insight into the types and nature of the labour market adjustments that may have occurred. This insight is important for improving subsequent forecasts.

[1] Department of Manpower and Immigration, Annual Reports, Supply and Demand: New University Graduates; and Statistics Canada, Monthly Reports on Current Job Vacancies, Ottawa.

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